CS513/EE506/CS4514 Intro to Local and Wide Area Networks — WPI, Summer 2006
Craig E. Wills — Midterm Exam (100 pts)
Given: Wednesday, June 14, 2006

NAME:_____

This is a closed book (and notes) examination. Answer all questions on the exam itself. Take the number of points assigned to each problem and the amount of space provided for your answer as a measure of the length and difficulty of the expected solution. The exam totals 100 points.

Potentially useful formulas:

- Nyquist rule for a noiseless channel:
  max data rate = $2H \log_2 V$ bps where H is the bandwidth and V is the number of states encoded.
- Shannon's theorem for channels with noise:
  max data rate = $H \log_2(1 + S/N)$ bps where noise is measured in decibels (db) and db = $10 \log_{10} S/N$

SCORE:_____

1. (6 points) Fourier showed that any reasonably behaved periodic function can be rewritten as the sum of an infinite series of harmonics. What is the implication of this fact for data transmission on media that filter frequencies outside of a frequency spectrum?

2. (10 points) Television channels are 6MHz wide. How many bits/sec can be sent if four-level digital signals are used? Would this data rate change if a channel had a signal-to-noise ratio of 30 dB? If so, indicate the maximum data rate for this noisy channel.

3. (10 points) In an M/M/1 queueing model, the number of customers in the system can be expressed as $N = \rho/(1-\rho)$.

   (a) What is ρ and what property must it satisfy?

   (b) Assume that measurements for a network router show that packets arrive at a mean rate of 500 packets per second (pps) with an exponential distribution for interarrival time. On average, the router takes 1ms to forward each packet where the forwarding time also has an exponential distribution. What is the mean number of packets in the router?

   (c) Now assume that the router always takes a constant 1ms to forward each packet. What is the mean number of packets in the router? You may want to use the Pollaczek-Khinchine equation for an M/G/1 queueing system where C_b is the ratio of the standard deviation to the mean of the service time probability density function.

$$N = \rho + \rho^2 \frac{1 + C_b^2}{2(1-\rho)}$$

4. (12 points) Consider the following CRC calculation used to determine the checksum to send for a given frame of data.

```
Frame: 11001101
Generator: 1011
Msg after 3 bits appended: 11001101000

          11101010
     -------------
1011 | 11001101000
       1011
       ----
        1111
        1011
        ----
         1001
         1011
         ----
           1001
           1011
           ----
             1000
             1011
             ----
               110
```

(a) What is the generator *polynomial* used?

(b) What is the CRC checksum for this frame?

(c) What is the message that is transmitted?

(d) What will the receiver do with received message?

(e) Is it possible for a message to be received by the receiver that is accepted as good, but it is not the message that was sent? If you answer "yes" then indicate such a message. If you answer "no" then explain why not.

5. (15 points) Frames of are sent over a 1Mbps channel with a one-way propagation delay of 5ms. The header size is negligible.

   (a) How big (in bits) must the frames be for the sender to achieve a maximum channel utilization of 50% using stop-and-wait (protocol 4)?

   (b) Is it possible for the sender to achieve a maximum channel utilization of 100% using stop-and-wait (protocol 4)? If so, indicate how. If not, indicate why not?

   (c) Is it possible for the sender to achieve a channel maximum utilization of 100% using a different sliding window protocol? If so, indicate how. If not, indicate why not?

6. (8 points) Define baud rate and data rate in the context of data transmission. Give examples (or explain why it is not possible) for one rate to be greater than, equal to or less than the other.

7. (10 points) The following shows four sets of network conditions where the one-way latency is relatively low or high and the network error rate is relatively low or high. For each combination of latency and error rate, indicate which protocol: stop-and-wait (protocol 4), go back n (protocol 5) or selective repeat (protocol 6) would be the most appropriate choice to use for the given network condition along with a brief explanation of why. If more than one protocol is appropriate then indicate as much.

Error Rate	One-Way Latency	
	Low	High
Low		
High		

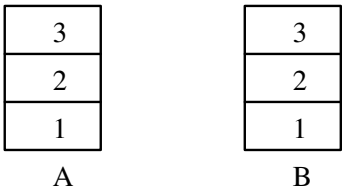
8. (9 points) An important function of the Data Link Layer is framing. Briefly describe and state a relative advantage and disadvantage of each of the following approaches to framing.

   (a) a character count at the beginning of the frame,

   (b) special bit (or character) delimeters at the beginning and end of a frame along with bit (or character) stuffing, or

   (c) encoding violations to indicate beginning and end of a frame.

9. (8 points) The following diagram shows the bottom three layers of the OSI reference model on two separate machines. Show the path of communication using the diagram when sending data from layer 3 on machine A to layer 3 on machine B? As part of your answer indicate any headers/trailers that are added to/removed from the data.



(a) Which layers on which machines would be affected if the *protocol* defined for layer 2 on machine A was changed?

(b) Which layers on which machines would be affected if the *interface* defined for layer 1 on machine A was changed?

10. (12 points) For this problem four stations (A, B, C, and D) are attached to a standard IEEE 802.3 1-persistent CSMA/CD LAN. Assume all messages take one time unit to transmit. At time zero, Station D transmits a message. At time 0.5, the three other stations each have a message ready to send. No more messages will be sent.

    (a) At time one a collision will occur. How many stations contribute to the collision?

    (b) After the collision what is the probability that no contention will occur in the first round of the binary exponential backoff algorithm?

    (c) If contention does occur in round one, does contention also have to occur in round two? Explain if appropriate.

    (d) If contention does not occur in round one, is there guaranteed to be further collisions? Explain if appropriate.